Northwest **Power** and **Conservation** Council



January 3, 2018

**MEMORANDUM**

**TO:** **Council members**

**FROM:** **Patty O'Toole, Program Implementation Manager**

**SUBJECT:** **Update on ocean conditions**

## BACKGROUND:

Presenters: Laurie Weitkamp (Northwest Fisheries Science Center), Patty O'Toole

Summary: At the January meeting the Council will receive an update on recent ocean conditions for salmon and steelhead. Laurie Weitkamp from the Northwest Fisheries Science Center will review recent physical conditions in the areas of the Columbia River Plume and near ocean where Columbia River salmon reside for one to three years. Laurie will also present information about the biological response to these conditions and what this may mean for Columbia River salmon. Staff will also provide a brief update on the Ocean and Plume Science and Management Forum.

Relevance: The Council's Fish and Wildlife Program (Plume and Nearshore Ocean strategy) calls for monitoring plume and ocean conditions and assessing the impacts on salmonid survival.

Background: The Northwest Fisheries Science Center, with funding provided through the Council's Program (Bonneville) and the Anadromous Fish Evaluation Program (Corps) conducts research in the estuary, plume and nearshore ocean aimed at understanding how physical and biological conditions affect salmon. For more information see: Ocean ecosystem indicators, Ocean and Plume Science and Management Forum.

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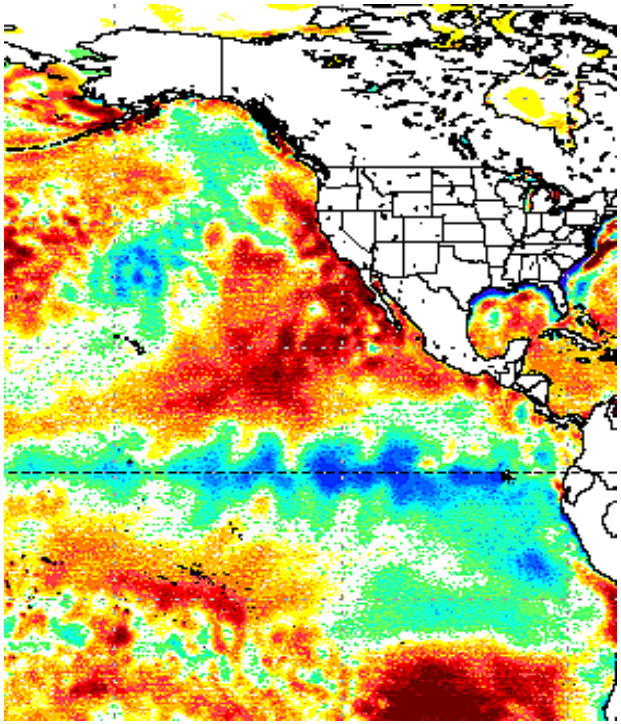
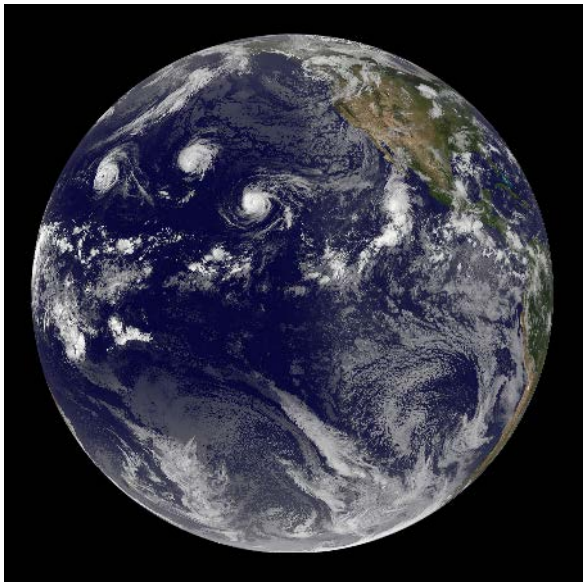
# Update on ocean conditions




Laurie Weitkamp
Northwest Fisheries Science Center
Newport Field Station
NOAA Fisheries
Laurie.weitkamp@noaa.gov

# Today's talk

1. Columbia River salmon use of marine waters
2. Physical conditions across the North Pacific
3. Biological response to physical conditions
4. Forecasts



# 1. Columbia River salmon use of marine waters

## Why does it matter?

Each species (and/or stock) uses the ocean differently. They …

- enter at different sizes, ages, times
- go to different places
- eat different things
- return after different amounts of time at one or multiple ages

**Collectively this determines their marine survival (=how many return as adults)**

# First summer in the ocean: three patterns for Columbia River salmon

Pattern 1: Rapid north-wards movement on shelf to Gulf of Alaska

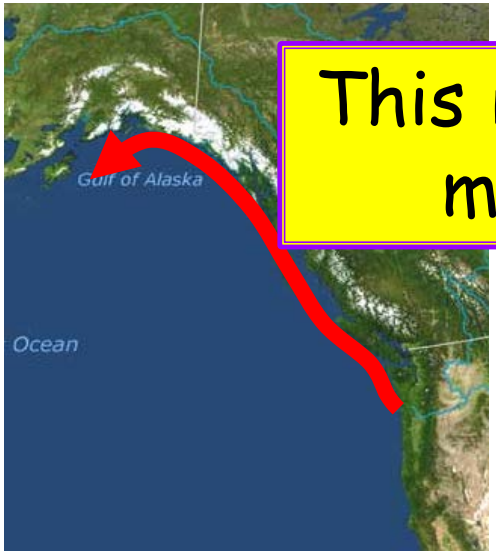
Which: Spring Chinook, chum, sockeye, some coho

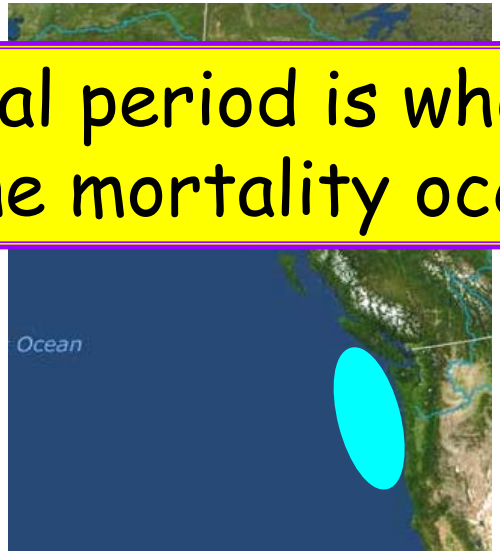
Pattern 2: Remain in local waters

Which: Fall Chinook, some coho

Pattern 3: Move rapidly offshore

Which: Steelhead



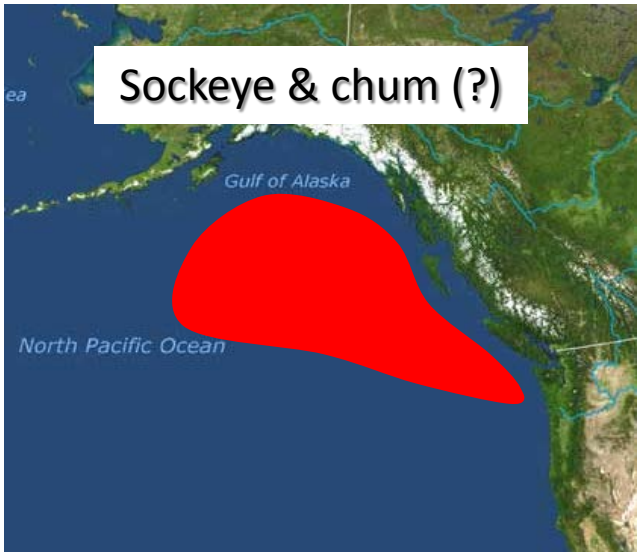





This initial period is when most marine mortality occurs

# Columbia River high seas distributions






# Adults returning to the Columbia: three general migration patterns

Pattern 1: Southwards movement along shelf

Which: Fall Chinook, Chum (?), sockeye (?)


Pattern 2: Northwards along California & Oregon Coasts

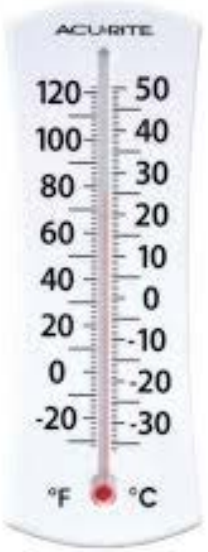
Which: Coho


Pattern 3: Move rapidly onshore (or unknown)

Which: Steelhead, Spring Chinook

# 2. Physical conditions across the North Pacific

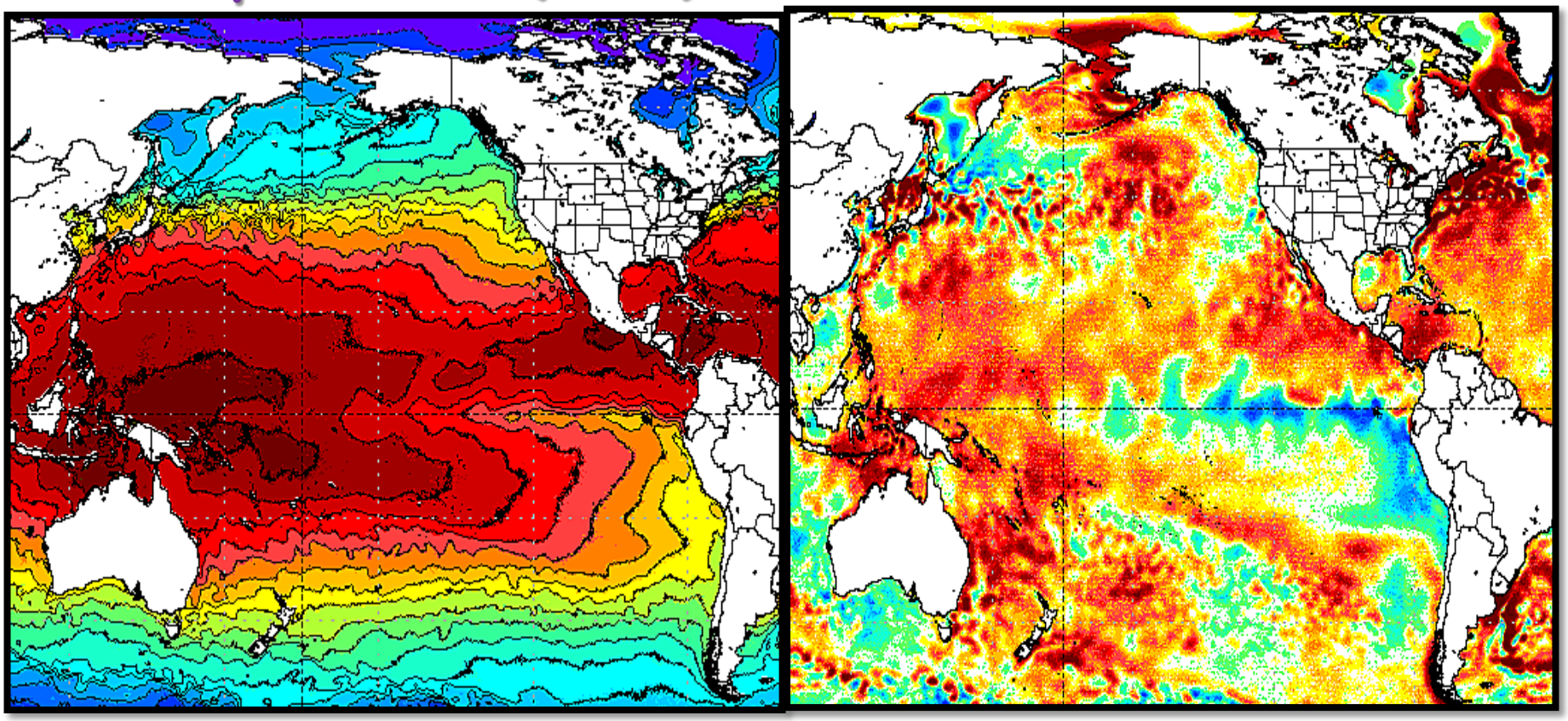
- Anomalies explained
- Why the blob formed
- Recent sea surface temperature (SST) anomalies



# Terminology: Anomaly

**Actual sea surface temperature (SST)**

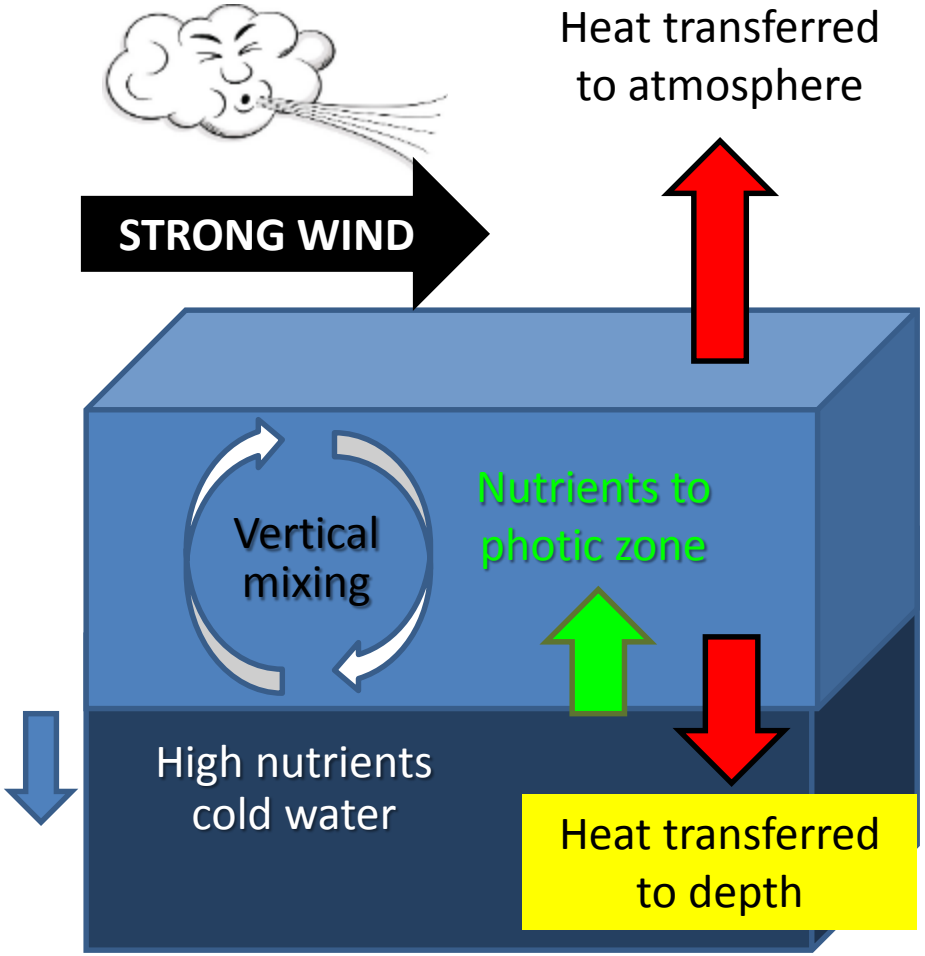
**SST anomalies**



http://polar.ncep.noaa.gov/sst/ophi/

# How the blob formed

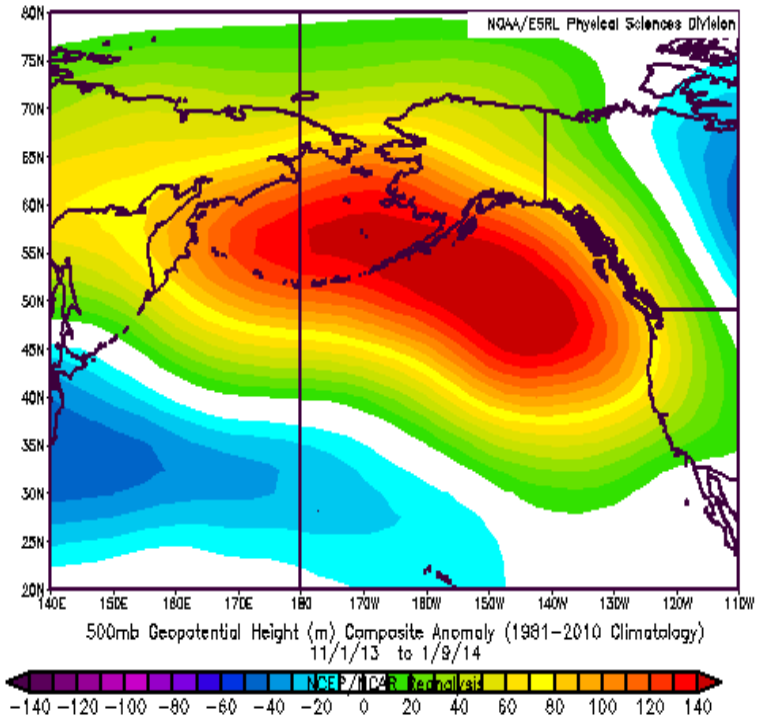
## Winter storms mix and cool the ocean



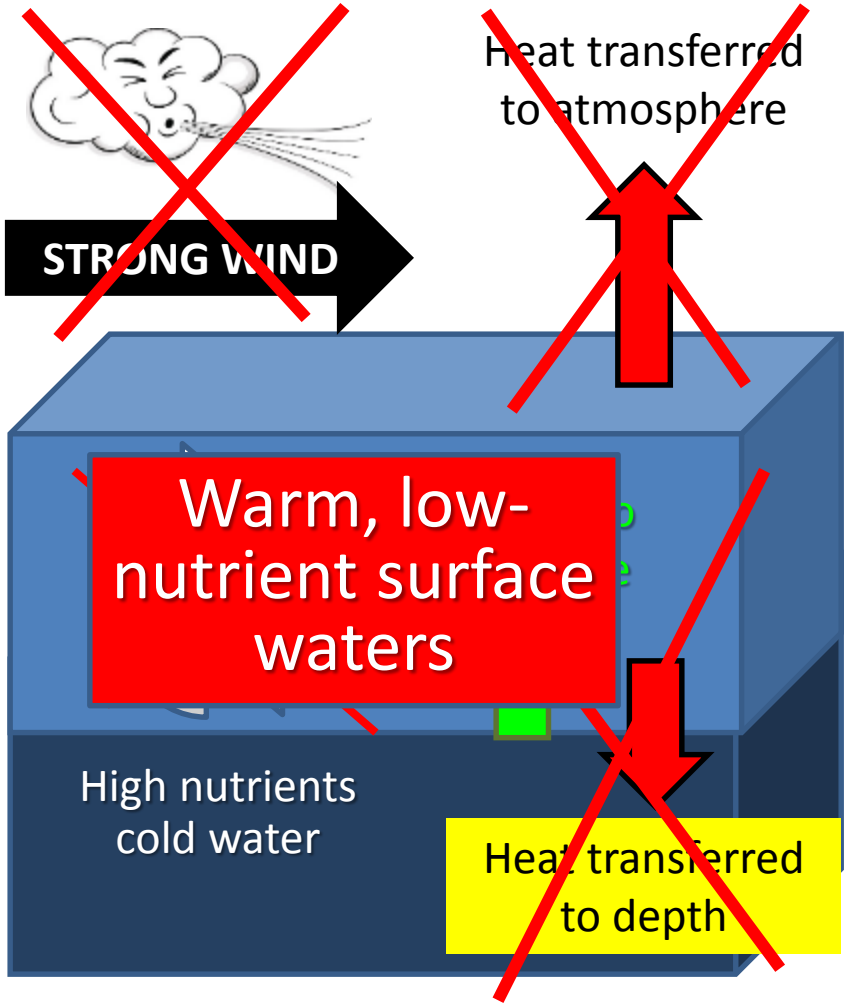
# Formation of the warm blob (Winter 2013/14):

Unusually stationary high pressure over the North Pacific blocked storms, which limited vertical mixing

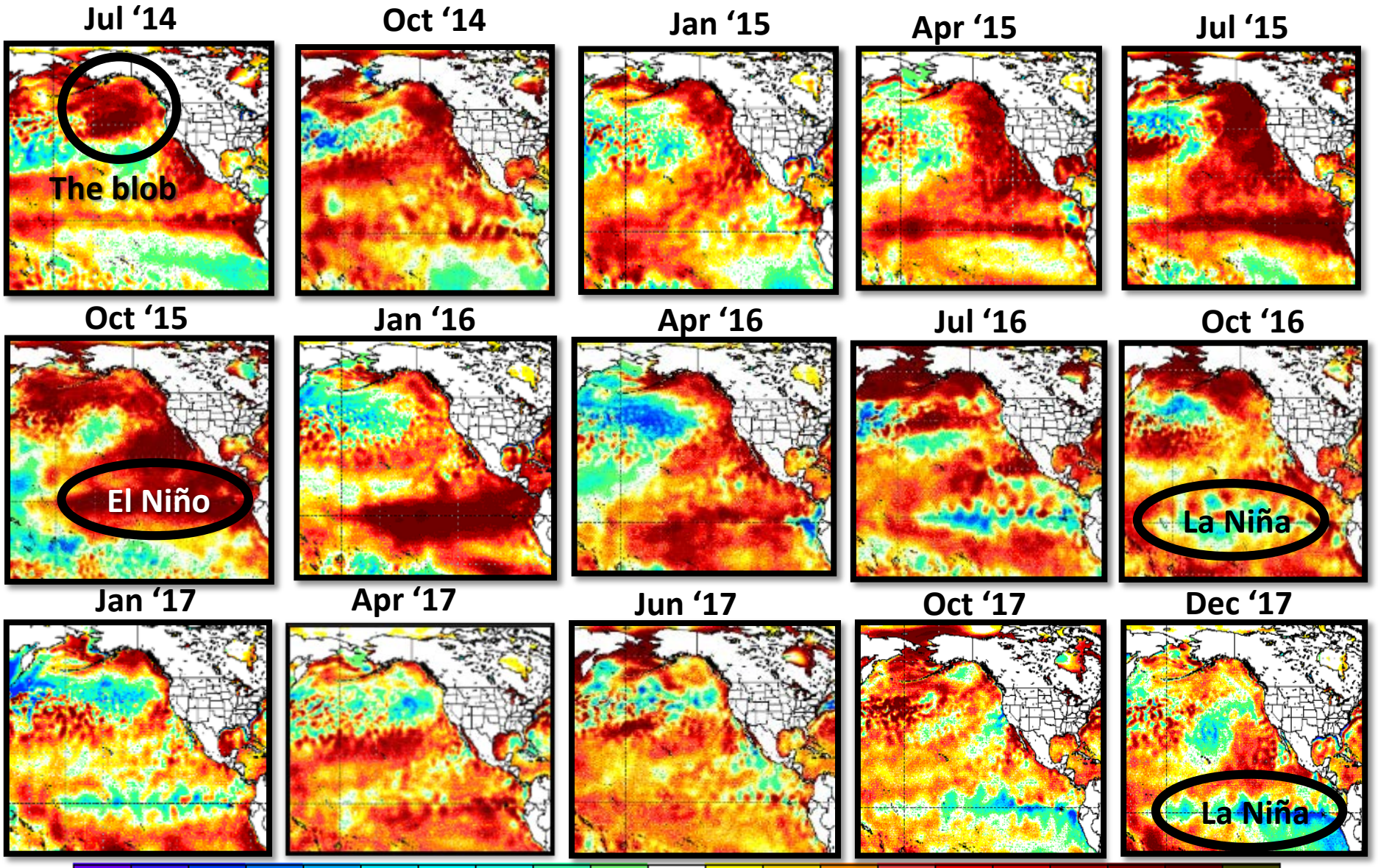
**Ridiculously resilient ridge**




Atmospheric pressure anomalies, Nov 1, 2013-Jan 9, 2014

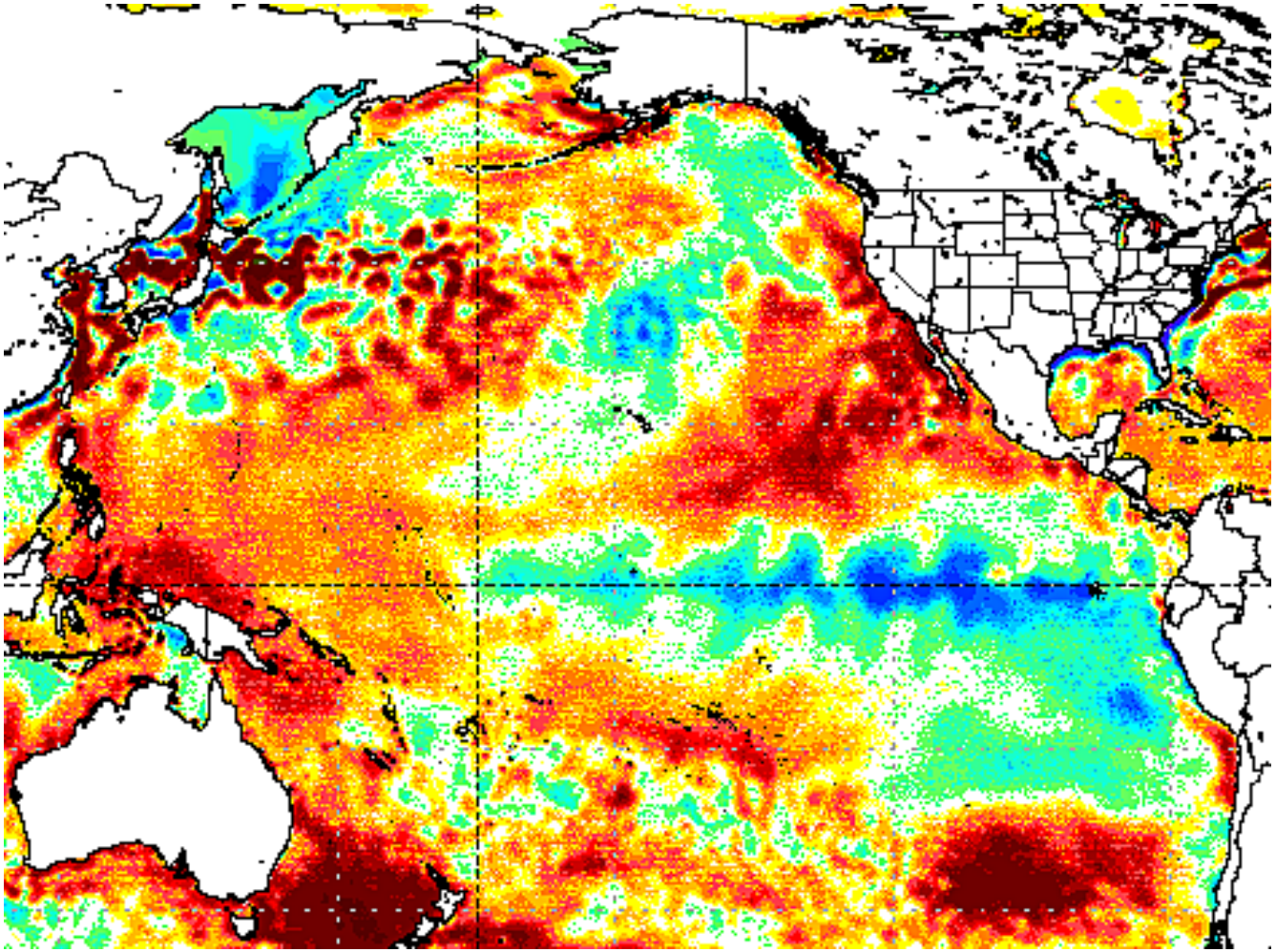


# North Pacific surface temperature anomalies




http://polar.ncep.noaa.gov/sst/ophi/

# SST anomalies, 3 January 2018



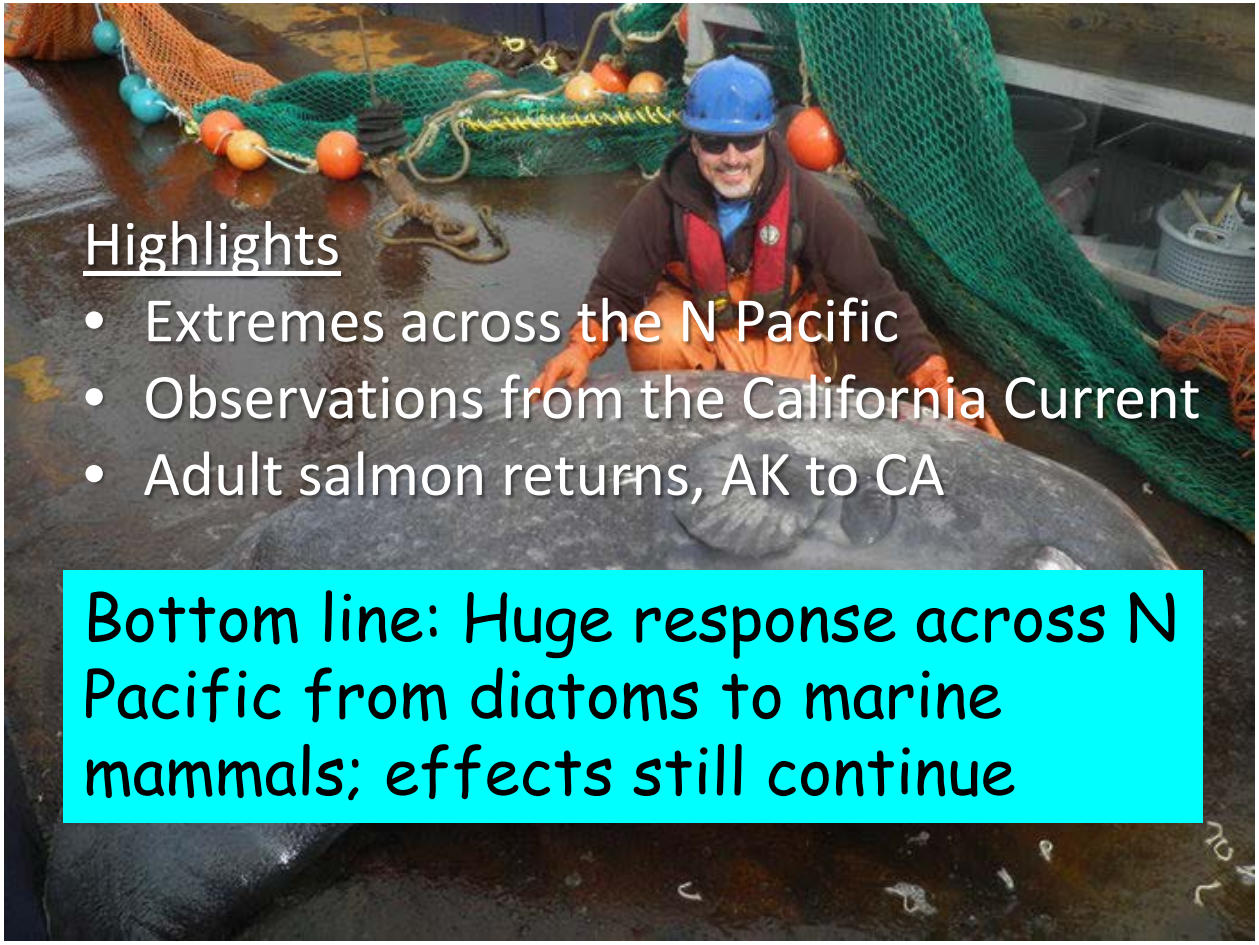
−8 −4 −2.25 −1.75 −1.5 −1.25 −1 −0.75 −0.5 −0.25 0.25 0.5 0.75 1 1.25 1.5 1.75 2.25 4 8

degrees C

):51 WED JAN 6 2016

http://polar.ncep.noaa.gov/sst/ophi/

# 3. Biological response to physical conditions




Joe Orsi (AFSC) with ocean sunfish in SE Alaska, June 2015

# Biological response to warm oceans off WA/OR

## 2015

Tropicals In Oregon



Species range extensions from CA to AK

Dramatic changes to food webs

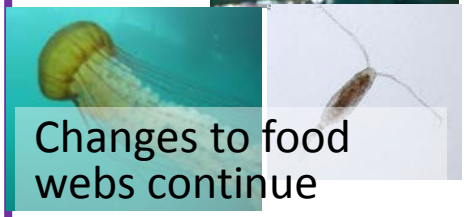
Domoic acid closes crab and clam fisheries AK-CA

Young Chinook & coho in ocean very skinny

## 2016

Red pelagic crabs in Oregon!

Anchovies invade the Salish Sea



Changes to food webs continue

Crab and clam fishery closures

## 2017

High Pacific lamprey counts at Bonneville Dam

Pyrosomes explode AK-CA

Swordfish off Vancouver Island

Extremely low Pacific cod abundance in Gulf of Alaska

Crab and clam fishery closures

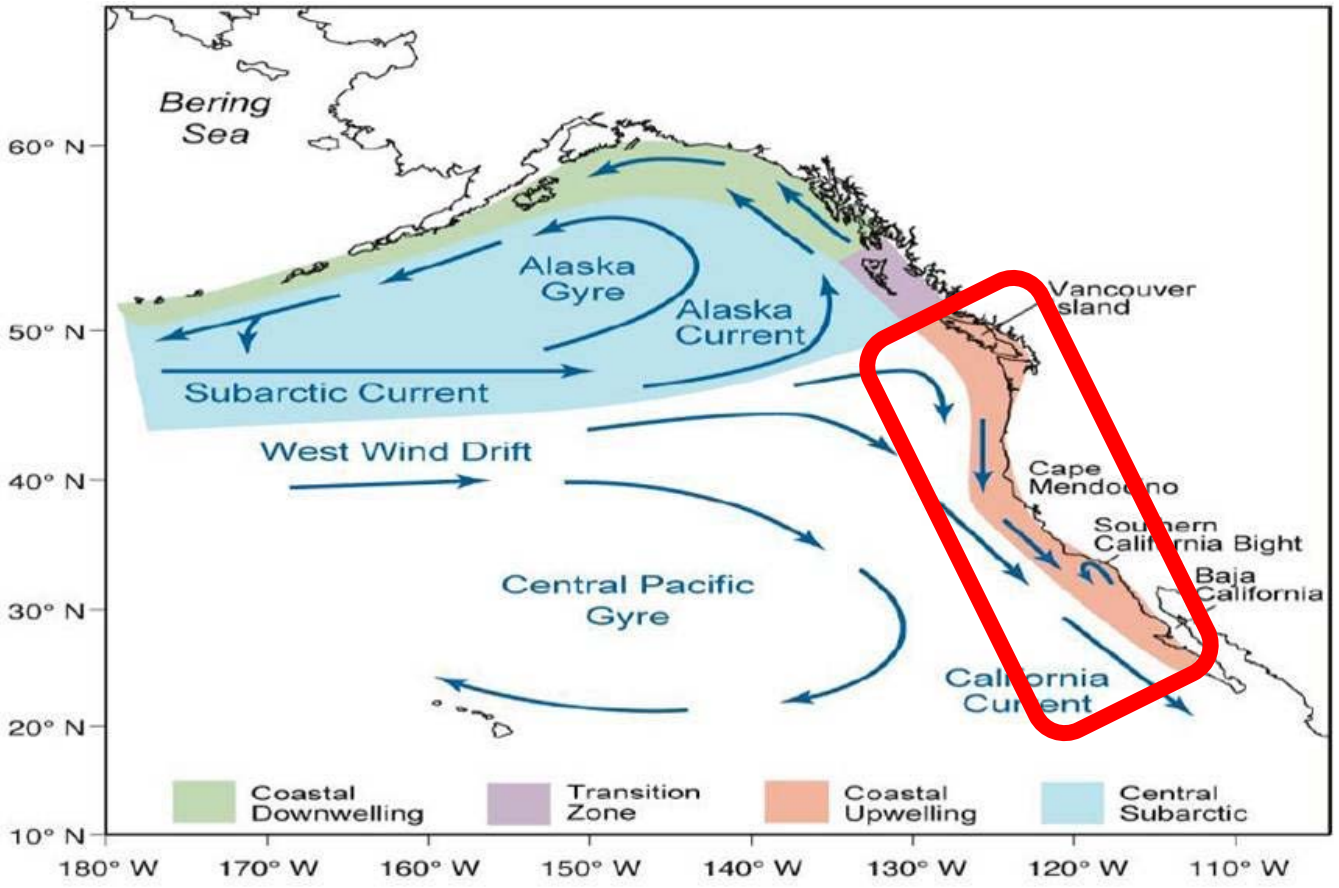
# Bad conditions elsewhere can affect our area: California sea lions left S. California for greener pastures in the Columbia

2015: starving sea lion pups in California

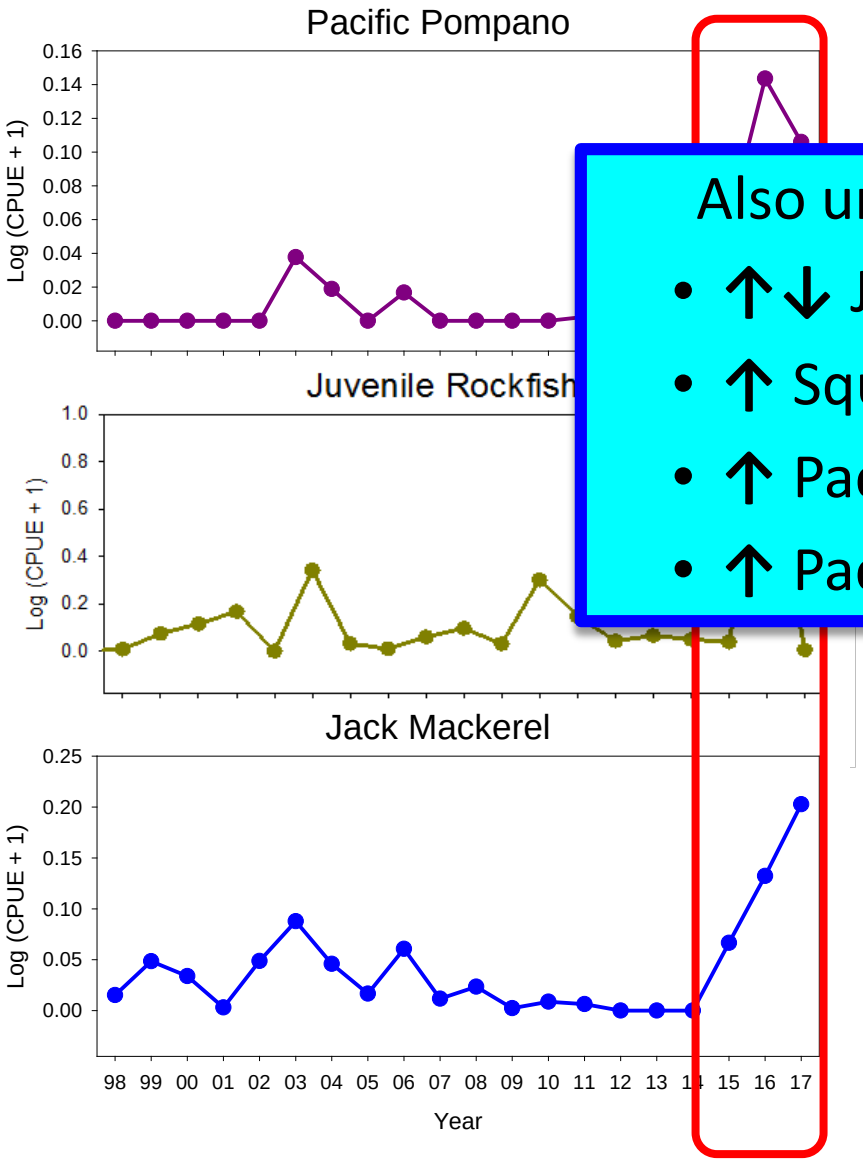



Source: Bryan Wright, ODFW

# Biological response in California Current



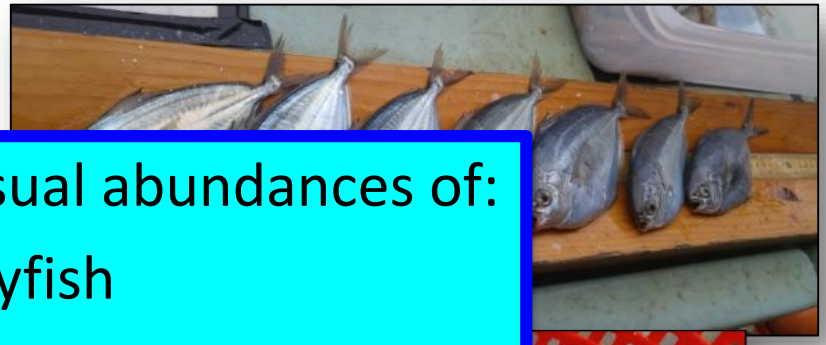
# Unusual abundances of many fishes in NWFSC Salmon Surveys




Morgan et al. in prep.

Also unusual abundances of:

- ↑↓ Jellyfish
- ↑ Squid
- ↑ Pacific mackerel
- ↑ Pacific hake



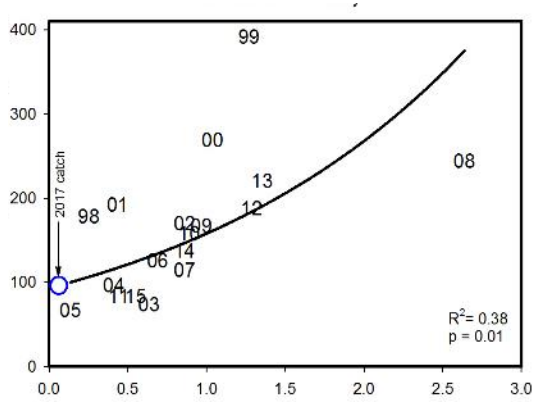
Age 0 fish = Salmon **prey**

Age 1-2 fish = Salmon **competitors**

Age 3-4 fish = Salmon **predators**

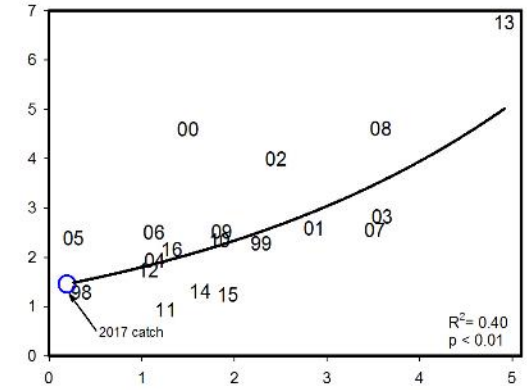
# Extremely low juvenile salmon abundances in 2017 will likely result in poor adult returns in 2018 & 2019

Spring Chinook counts at BON 2 yrs later

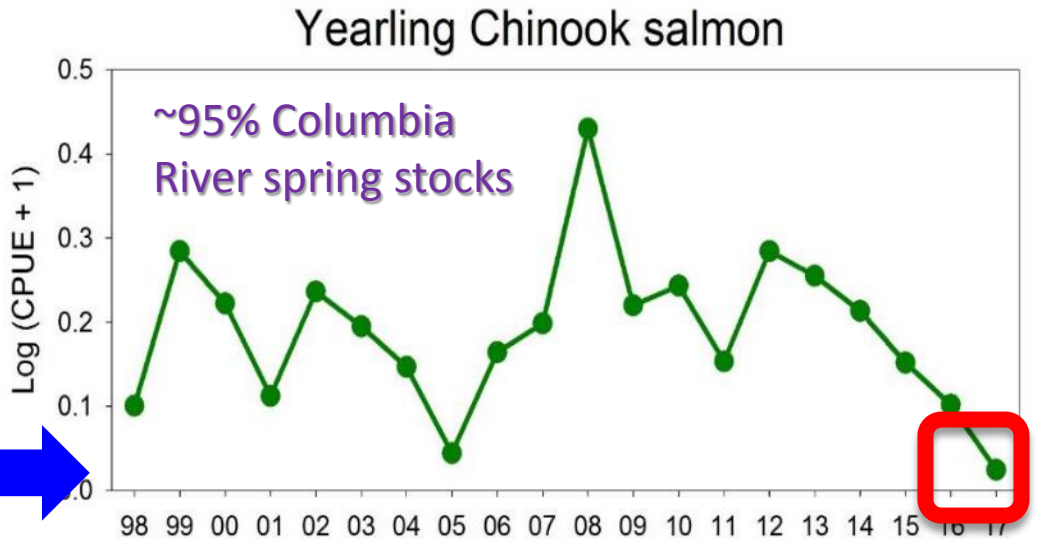


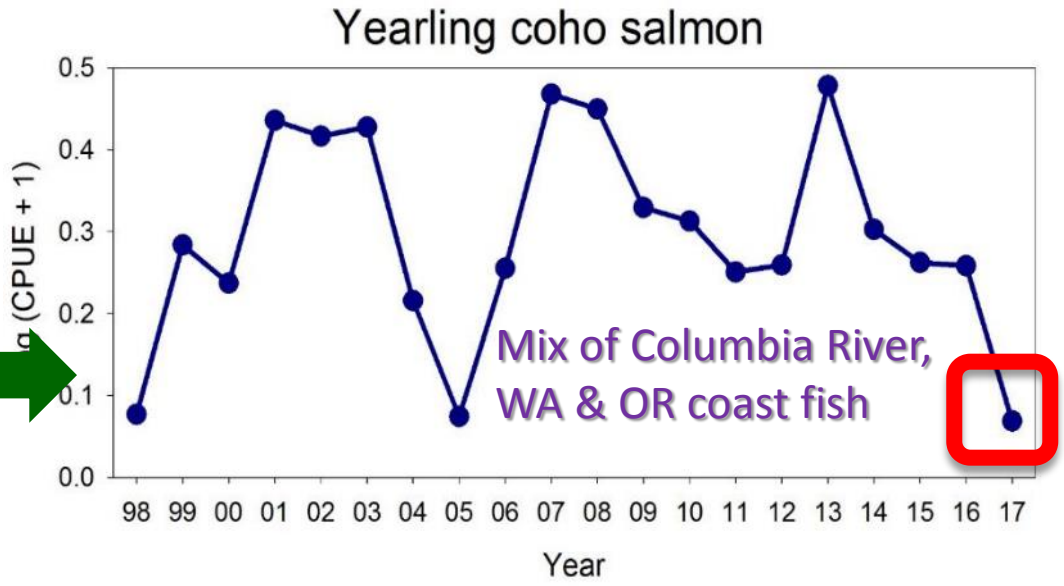

Juvenile Chinook in surveys

Coho survival (OPI) 1 year later

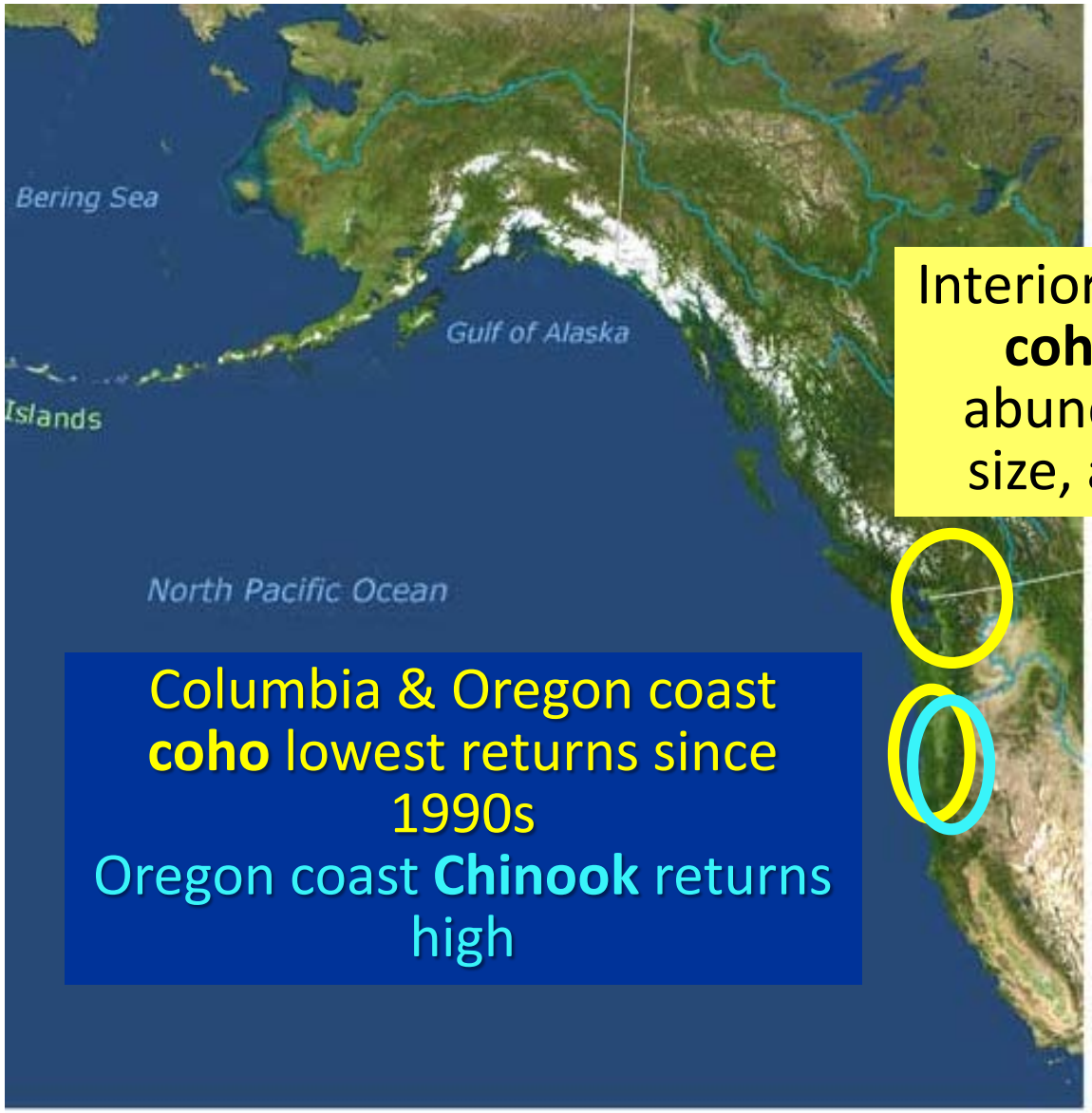



Juvenile coho in surveys

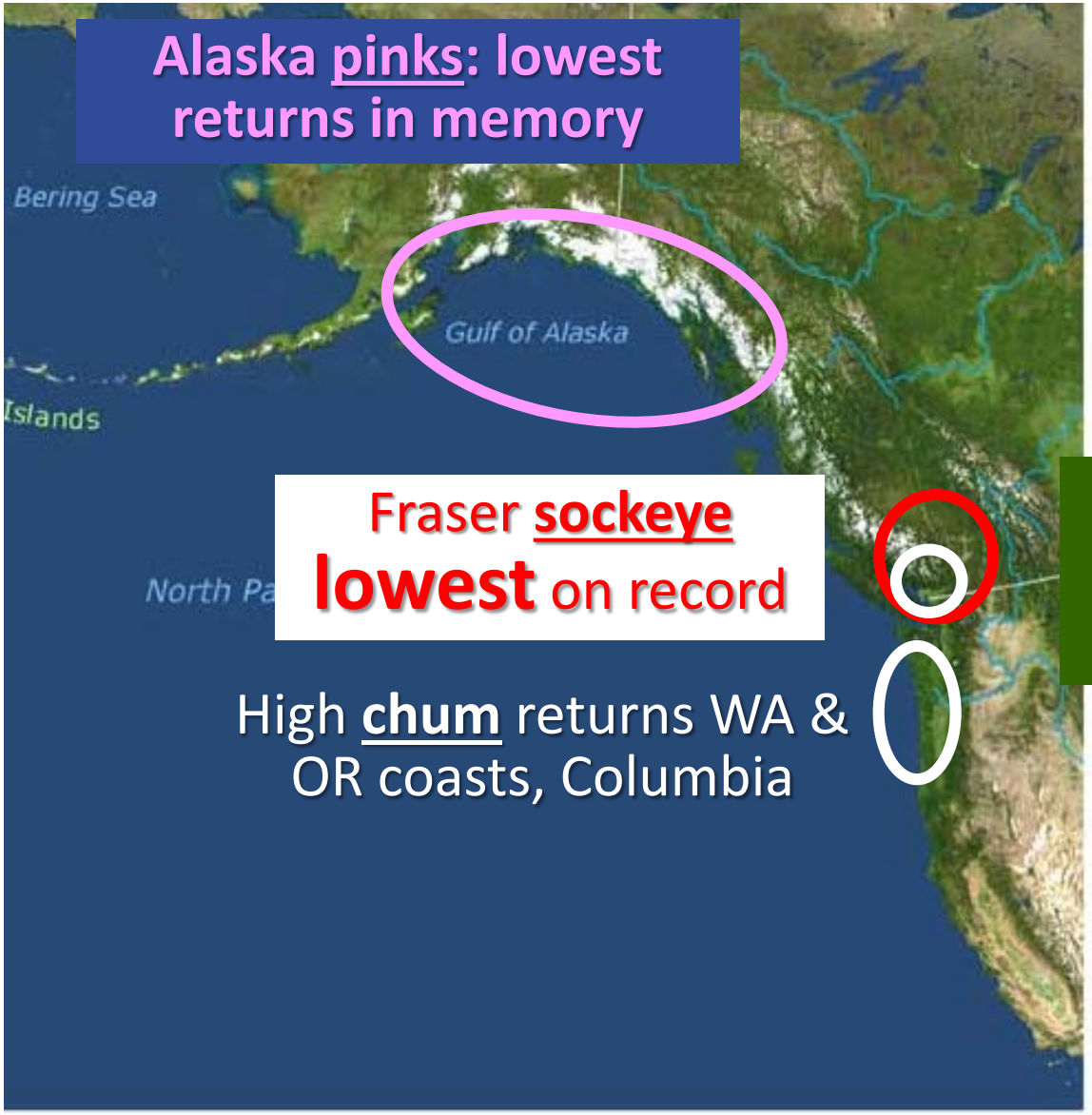


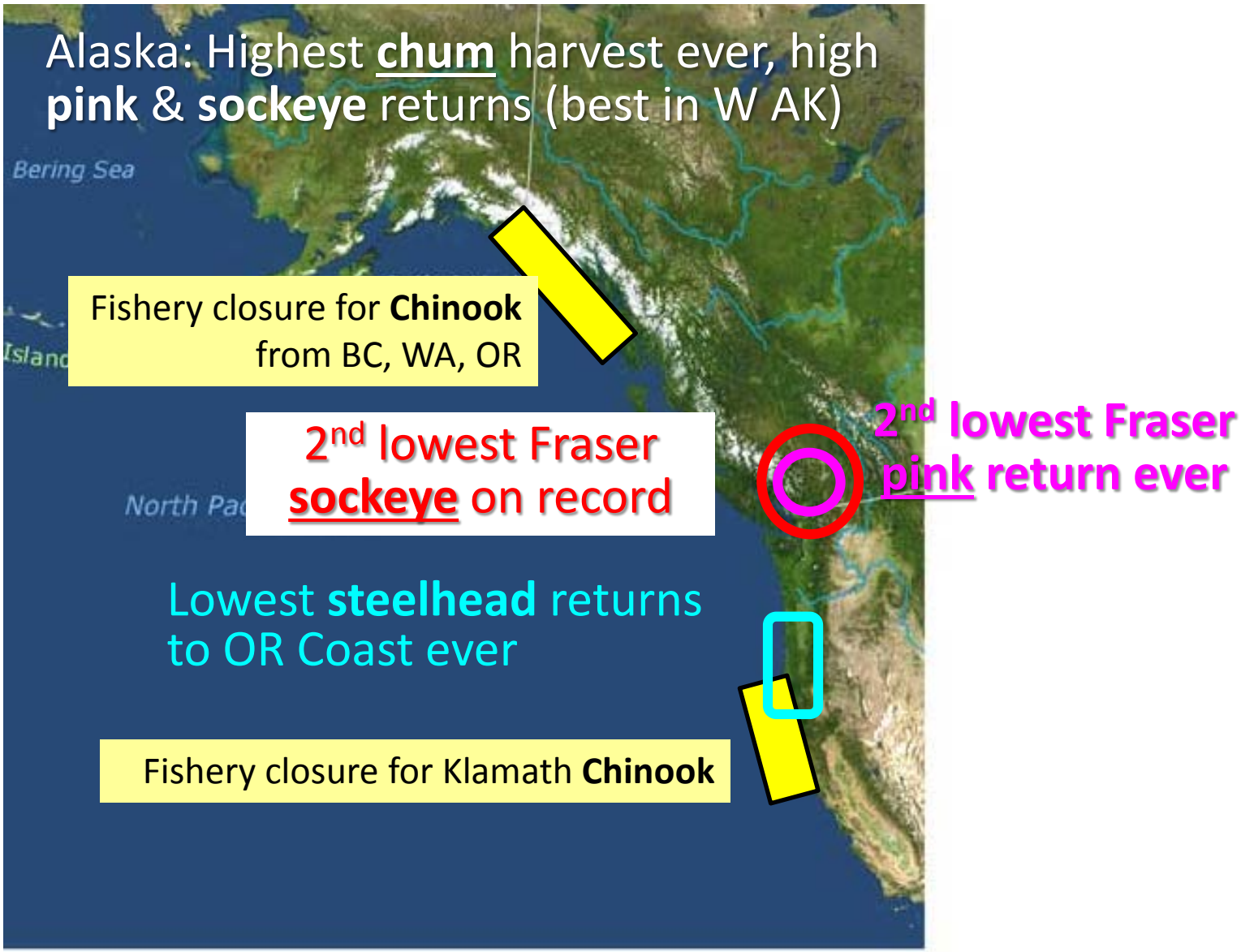
# Unusual adult salmon observations in **2015**



# Unusual adult salmon observations in **2016**



# Initial salmon observations in **2017**



# 4. Forecasts

- Bill Peterson's stoplight table
- Spring 2018 SST forecasts

# Bill's stoplight rankings

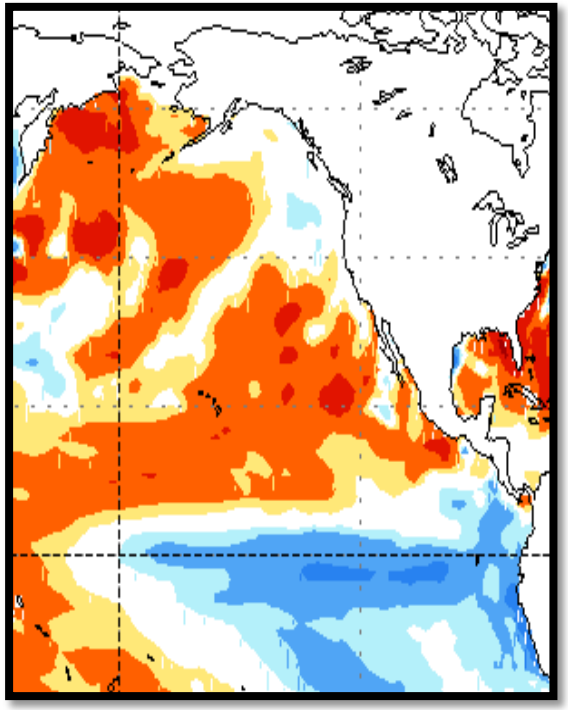
www.nwfsc.noaa.gov

| | | Year | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Ecosystem Indicators* | *1998* | *1999* | *2000* | *2001* | *2002* | *2003* | *2004* | *2005* | *2006* | *2007* | *2008* | *2009* | *2010* | *2011* | *2012* | *2013* | *2014* | *2015* | *2016* | *2017* |
| Ocean basin | PDO (Sum Dec-March) | 17 | 6 | 3 | 12 | 7 | 19 | 11 | 15 | 13 | 9 | 5 | 1 | 14 | 4 | 2 | 8 | 10 | 20 | 18 | 16 |
| | PDO (Sum May-Sept) | 10 | 4 | 6 | 5 | 11 | 16 | 15 | 17 | 12 | 13 | 2 | 9 | 7 | 3 | 1 | 8 | 18 | 20 | 19 | 14 |
| | ONI (Average Jan-June) | 19 | 1 | 1 | 6 | 13 | 15 | 14 | 16 | 8 | 11 | 3 | 10 | 17 | 4 | 5 | 7 | 9 | 18 | 20 | 12 |
| | | | | | | | | | | | | | | | | | | | | | |
| Physical | 46050 SST (°C; May-Sept) | 16 | 9 | 3 | 4 | 1 | 8 | 20 | 15 | 5 | 17 | 2 | 10 | 7 | 11 | 12 | 13 | 14 | 19 | 18 | 6 |
| | Upper 20 m T (°C; Nov-Mar) | 19 | 11 | 8 | 10 | 6 | 14 | 15 | 12 | 13 | 5 | 1 | 9 | 16 | 4 | 3 | 7 | 2 | 20 | 18 | 17 |
| | Upper 20 m T (°C; May-Sept) | 16 | 12 | 14 | 4 | 1 | 3 | 20 | 18 | 7 | 8 | 2 | 5 | 13 | 10 | 6 | 17 | 19 | 9 | 15 | 11 |
| | Deep temperature (°C; May-Sept) | 20 | 6 | 8 | 4 | 1 | 10 | 12 | 16 | 11 | 5 | 2 | | 14 | 9 | 3 | 15 | 19 | 18 | 13 | 17 |
| | Deep salinity (May-Sept) | 19 | 3 | 9 | 4 | 5 | 16 | 17 | 10 | 7 | 1 | 2 | 14 | 18 | 13 | 12 | 11 | 20 | 15 | 8 | 6 |
| | | | | | | | | | | | | | | | | | | | | | |
| Biological | Copepod richness anom. (no. species; May-Sept) | 17 | 2 | 1 | 7 | 6 | 13 | 12 | 16 | 14 | 10 | 8 | 9 | 15 | 4 | 5 | 3 | 11 | 18 | 19 | 14 |
| | N. copepod biomass anom. (mg C $m^{-3}$; May-Sept) | 17 | 13 | 9 | 10 | 3 | 15 | 12 | 18 | 14 | 11 | 6 | 8 | 7 | 1 | 2 | 4 | 5 | 16 | 19 | 17 |
| | S. copepod biomass anom. (mg C $m^{-3}$; May-Sept) | 19 | 2 | 5 | 4 | 3 | 13 | 14 | 18 | 12 | 10 | 1 | 7 | 15 | 9 | 8 | 6 | 11 | 16 | 17 | 16 |
| | Biological transition (day of year) | 17 | 11 | 6 | 7 | 8 | 12 | 10 | 16 | 15 | 3 | 1 | 2 | 14 | 4 | 9 | 5 | 13 | 20 | 20 | 20 |
| | Ichthyoplankton biomass (log (mg C 1000 $m^{-3}$); Jan-Mar) | 20 | 11 | 3 | 7 | 9 | 18 | 17 | 13 | 16 | 15 | 2 | 12 | 4 | 14 | 10 | 8 | 19 | 5 | 6 | 1 |
| | Ichthyoplankton community index (PCO axis 1 scores; Jan-Mar) | 9 | 13 | 1 | 6 | 4 | 10 | 18 | 16 | 3 | 12 | 2 | 14 | 15 | 11 | 5 | 7 | 8 | 17 | 20 | 19 |
| | Chinook salmon juvenile catches (no. $km^{-1}$; June) | 18 | 4 | 5 | 15 | 8 | 12 | 16 | 19 | 11 | 9 | 1 | 6 | 7 | 14 | 3 | 2 | 10 | 13 | 17 | 20 |
| | Coho salmon juvenile catches (no. $km^{-1}$; June) | 18 | 7 | 12 | 5 | 6 | 2 | 15 | 19 | 16 | 4 | 3 | 9 | 10 | 14 | 17 | 1 | 11 | 8 | 13 | 20 |
| | | | | | | | | | | | | | | | | | | | | | |
| | Mean of ranks | 16.9 | 7.2 | 5.9 | 6.9 | 5.8 | 12.3 | 14.9 | 15.9 | 11.1 | 8.9 | 2.7 | 8.3 | 12.1 | 8.1 | 6.4 | 7.6 | 12.4 | 15.8 | 16.3 | 13.8 |
| | Rank of the mean rank | 20 | 6 | 3 | 5 | 2 | 13 | 16 | 18 | 11 | 10 | 1 | 9 | 12 | 8 | 4 | 7 | 14 | 17 | 19 | 15 |

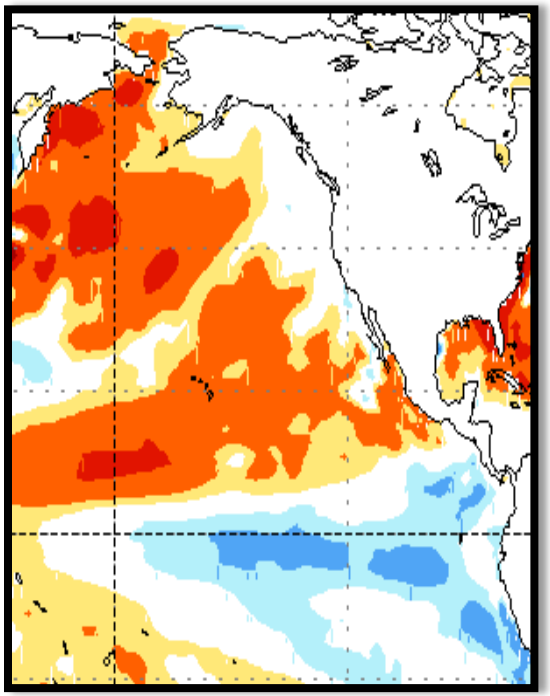
# Forecast SST anomalies

NOAA Climate prediction Center coupled forecast model 2

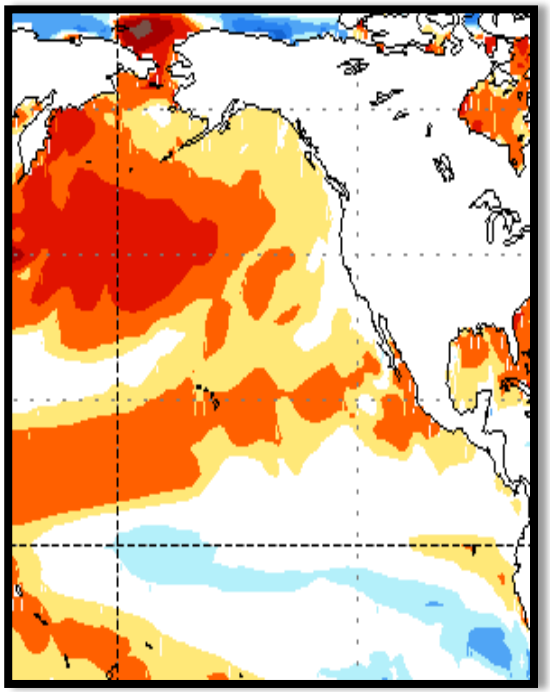
Feb-Mar-Jun 2018

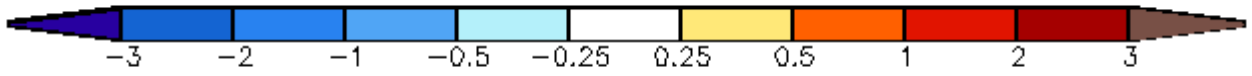


Apr-May-Jun 2018



Jun-Jul-Aug 2018



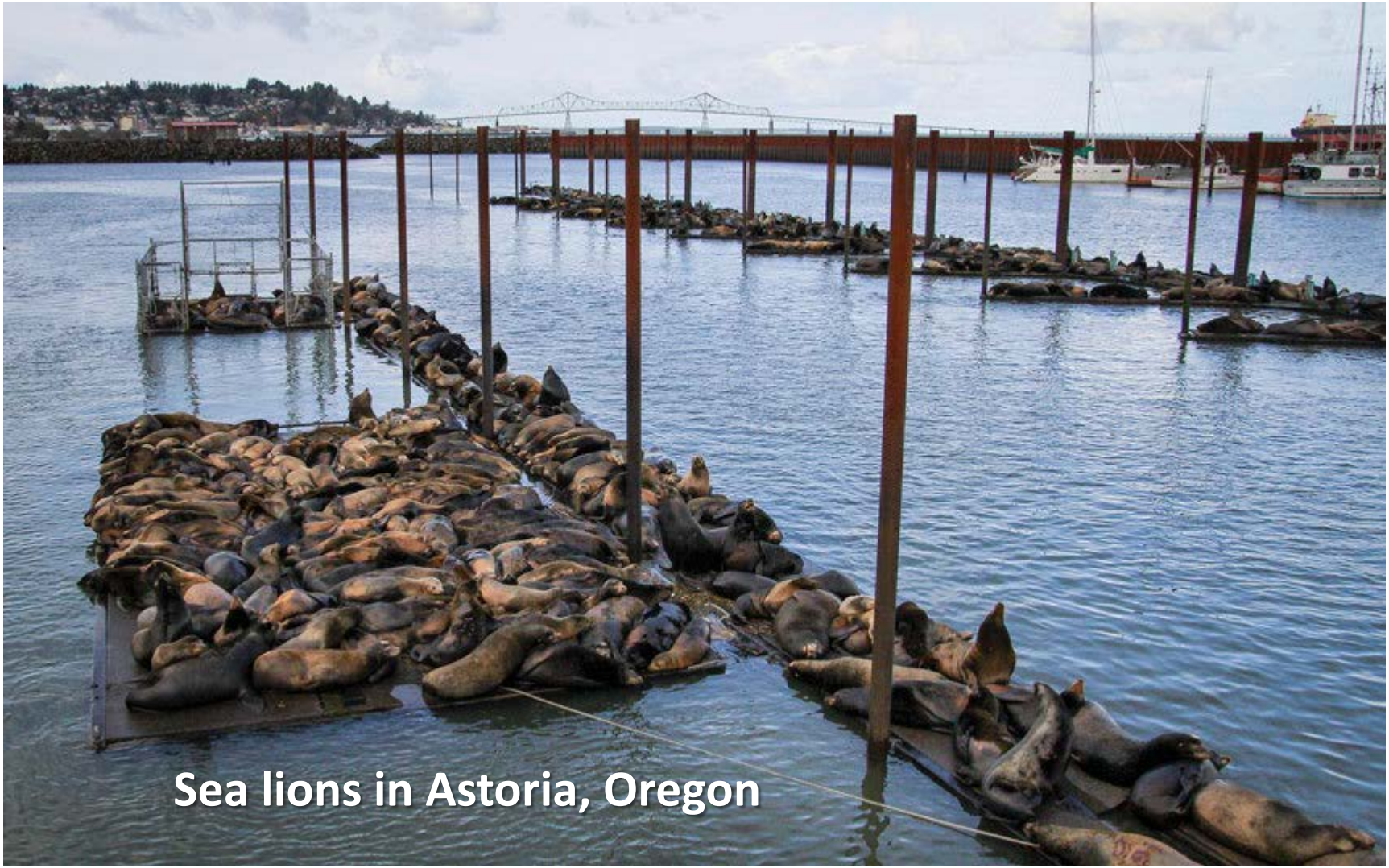



http://www.cpc.ncep.noaa.gov/products/CFSv2/CFSv2seasonal.shtml

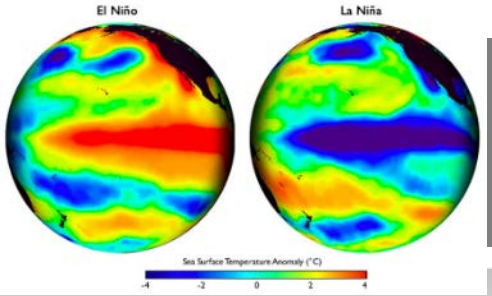
# Summary

- Warm ocean waters present since 2014 still continue across large parts of the North Pacific Ocean
- Biological response to warm ocean has been huge
  - Effects observed at all levels of marine ecosystem
- Expect biological effects of warm ocean conditions to continue for several years
  - Big concern for 2018 coho and 2019 Chinook returns because of low 2017 juvenile abundances
  - Big recruitment of hake & mackerel off WA/OR—will they stay?
  - Residual effects on other species (e.g., crab, groundfish) uncertain
- Cooler coastal waters forecast for spring 2018 should be good for young salmon entering the ocean.

# Questions?



# ENSO Summary




ENSO Alert System Status: La Niña Advisory

La Niña conditions are present.

Equatorial sea surface temperatures (SSTs) are below average across the central and eastern Pacific Ocean.

La Niña is likely (exceeding ~80%) through the Northern Hemisphere winter 2017-18, with a transition to ENSO-neutral most likely during the mid-to-late spring.

https://www.climate.gov/enso

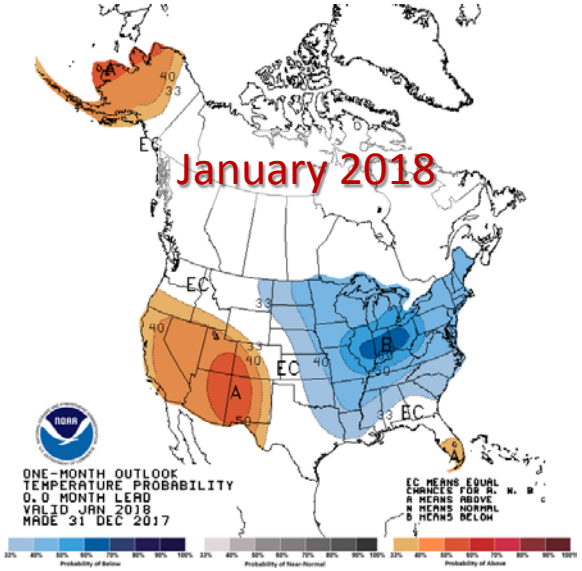
NOAA Climate.gov
science & information for a climate-smart nation

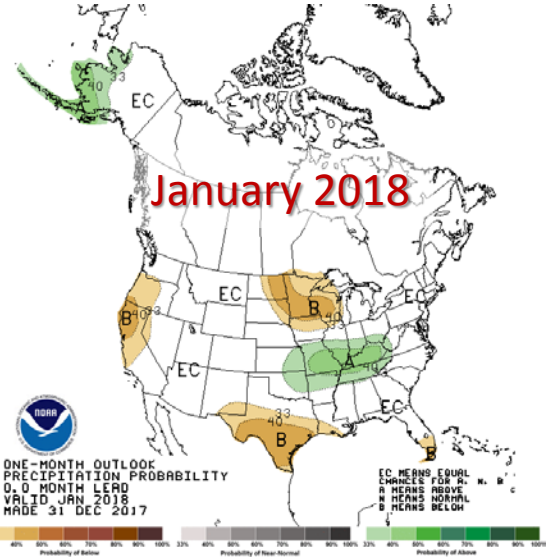
# Terrestrial outlooks

Temperature

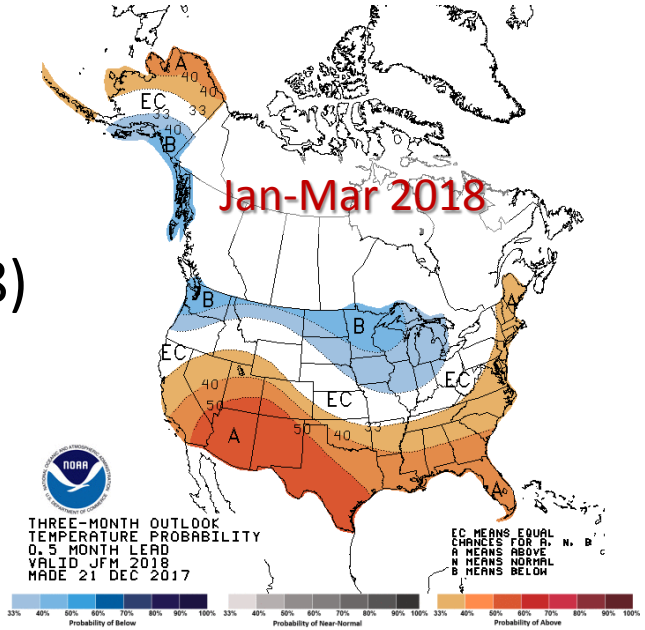
Precipitation

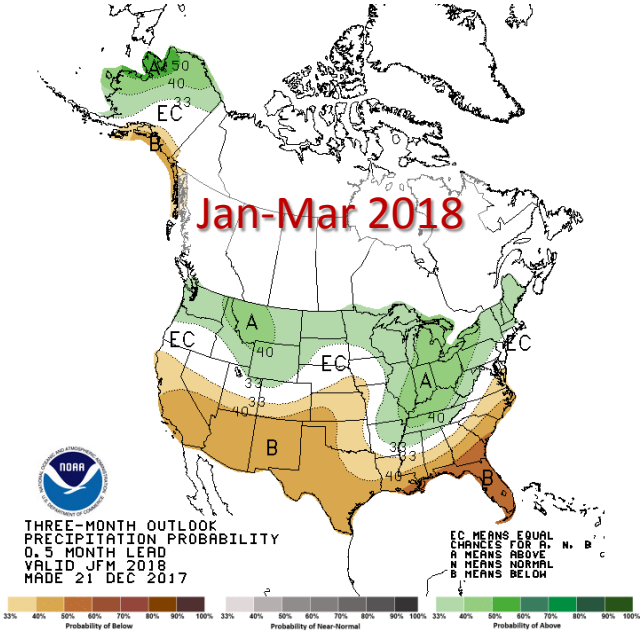
1 month (Jan)



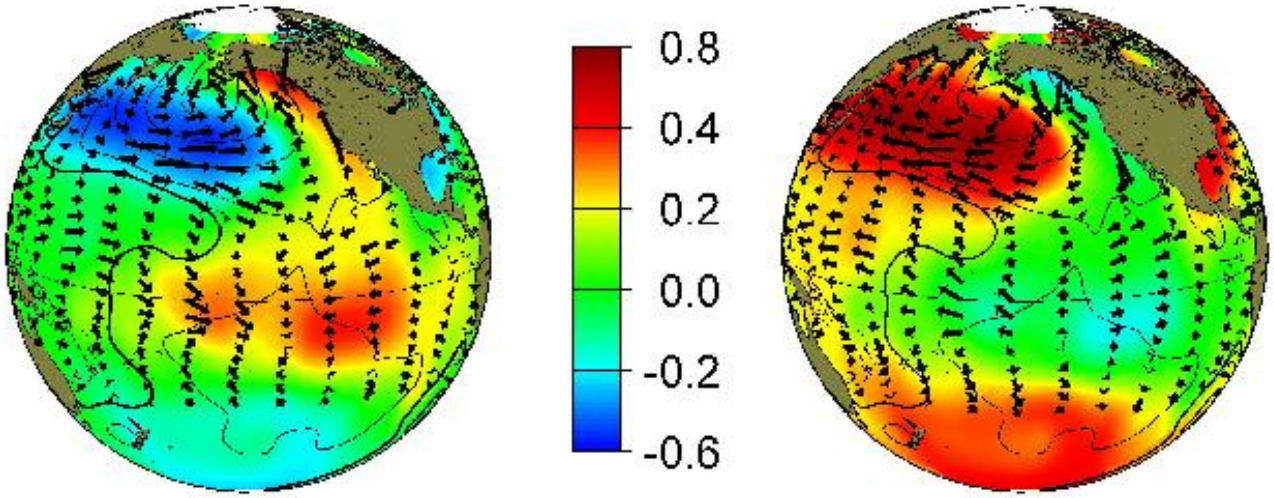

3 months (Jan-Mar 2018)



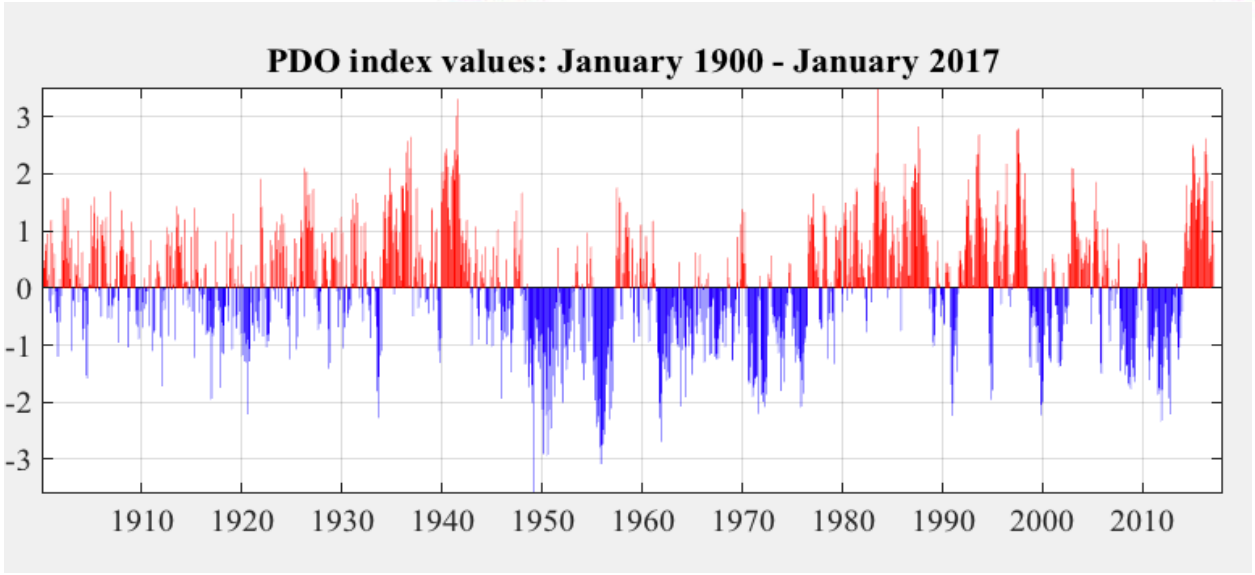



# Pacific decadal oscillation (PDO)

Warm (positive) phase



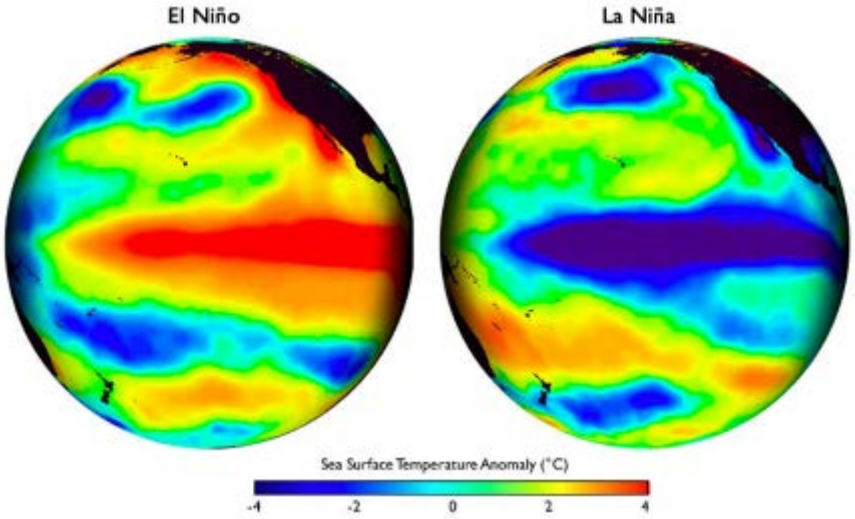

Cold (negative) phase



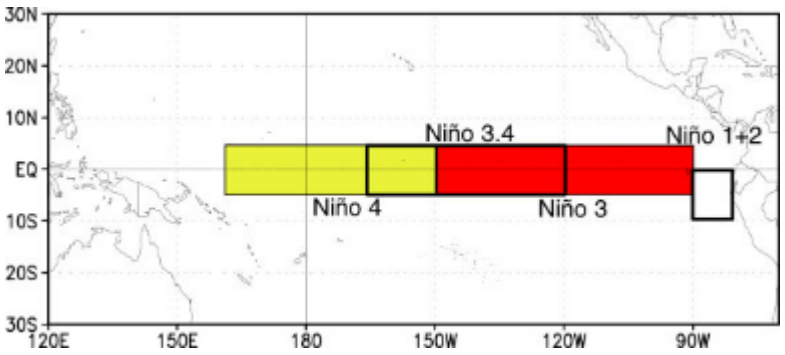

July-Sep ‘17: barely positive (0.09-0.32)

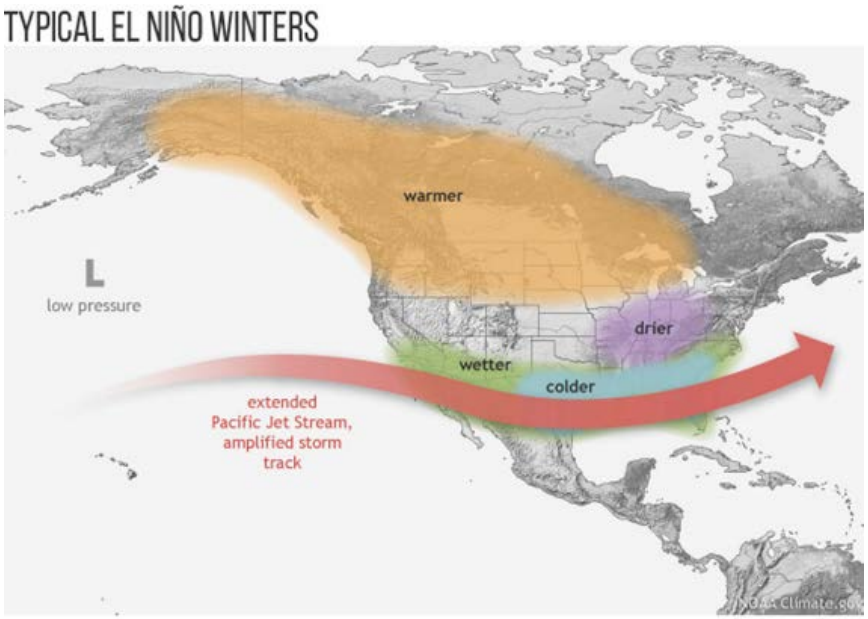
jisao.washington.edu

# El Niños and La Niñas: Impact global weather

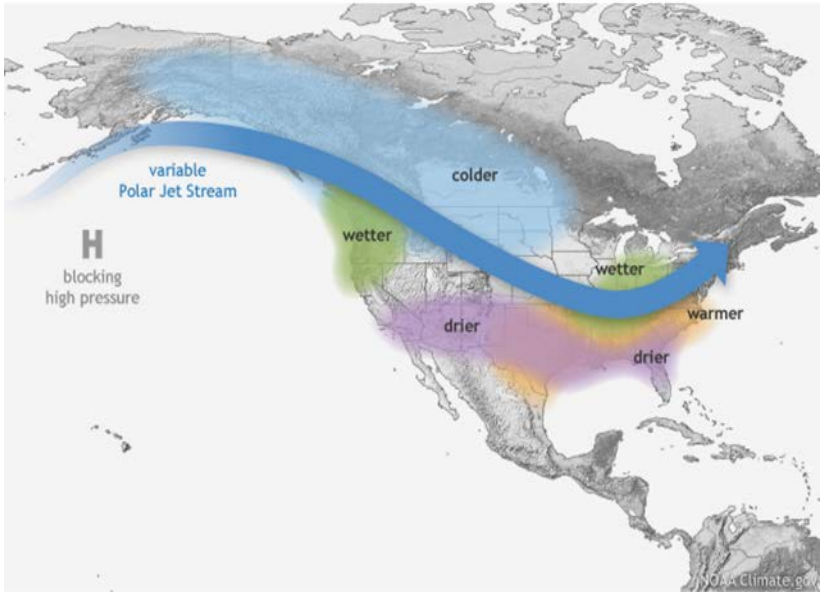



Measured as SST anomalies in Nino 3.4 area along equator




Wintertime La Niña pattern

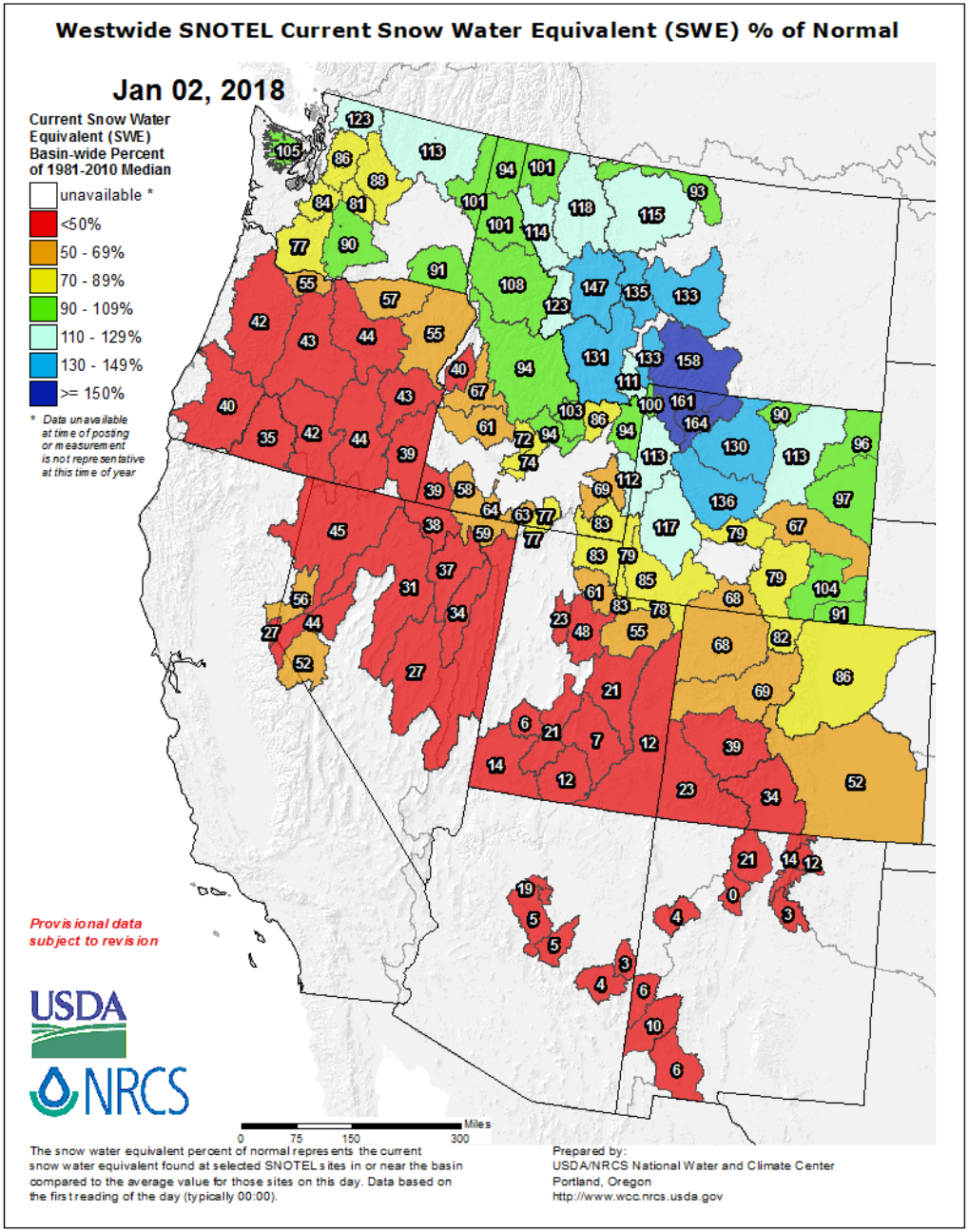


# Size and age at ocean entry and exit (Columbia River)

| Species | Age at ocean entry | Size at ocean entry | Years in ocean |
|---|---|---|---|
| Spring Chinook | 1 year | 5-7” | 1 (jacks)<br>2-4 (adults) |
| Fall Chinook | 2-4 months | 3-6” | 1 (jacks)<br>2-4 (adults) |
| Steelhead | 1 yr (hatchery)<br>2-3 yrs (wild) | 8-10” (hatchery)<br>6-8” (wild) | 1-2 |
| Coho | 1 year | 4-7” | 6 months (jacks)<br>1 (adults) |
| Sockeye | 1 year | 4-6” | 2-3 |
| Chum | 1-2 months | 2-3” | 3-5 |
| Pink* | 1 month | 2-3” | 2 |

* The Columbia River does not have a recognized pink salmon population.

# Westwide SNOTEL Current Snow Water Equivalent (SWE) % of Normal




The snow water equivalent percent of normal represents the current snow water equivalent found at selected SNOTEL sites in or near the basin compared to the average value for those sites on this day. Data based on the first reading of the day (typically 00:00).

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